Melting of Metals Under Ultrafast Heating by a Femtosecond Laser Pulse

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Commonly, in order to solve the problem of heat transfer, the Stefan problem is used. The melting area is supposed to be infinitely thin. In the present work, we analyze the melting under ultrafast femtosecond laser pulse action on metals. Our computational model is based on the electron heat-transfer equation considering the electron-ion exchange and a multiphase equation of state. We consider 3 variants: the Stefan problem with realistic heat capacity and heat of melting, the equilibrium melting with the finite melting zone, and the non-equilibrium melting with kinetics. The results of numerical simulations show that accounting for the melting kinetics diminishes the melting region in comparison with the equilibrium melting, but the melting zone width is non-negligible. We also take into account the rise of melting temperature of some metals with the increase of the electron temperature. The last effect significantly affects the heating process and can be observed experimentally.